

Exercise walk-through

Meiosis and Genetic Diversity ■ 5.2

eXercise

You must be able to

- explain **crossing over** 交叉互换 and **independent assortment** 自由组合
- explain how **random fertilization** adds variation
- link these to the diversity of offspring

Method — Three sources of variation

Meiosis and reproduction create genetic diversity by:

- 1 **Crossing over** — homologous chromosomes swap segments, making new gene combinations.
- 2 **Independent assortment** — homologous pairs line up randomly, so chromosomes are sorted into gametes in many combinations.
- 3 **Random fertilization** — any sperm can fertilize any egg.

Method — Crossing over

During meiosis I, homologous chromosomes exchange pieces, so a chromosome ends up with a **new mix** of alleles from both parents.

Method — Independent assortment

Each homologous pair lines up independently, so with n pairs there are 2^n possible gamete combinations from assortment alone.

Method — A worked count

Humans have 23 pairs, giving 2^{23} (over 8 million) combinations from independent assortment — before crossing over and random fertilization add even more.

Practice 2.1 ■ 1 mark

Name the process where homologous chromosomes swap segments.

Solution 2.1

Method: Three sources of variation

Worked steps

Crossing over **B1**.

Practice 2.2 ■ 1 mark

What does independent assortment describe?

Solution 2.2

Method: Independent assortment

Worked steps

Homologous pairs line up randomly, so chromosomes sort into gametes in many combinations **B1**.

Practice 2.3 ■ 2 marks

For an organism with 3 chromosome pairs, how many gamete combinations arise from independent assortment?

Solution 2.3

Method: Independent assortment

Worked steps

$2^3 = 8$ combinations **M1** **A1**.

Exam-style 3.1 ■ 1 mark

Crossing over increases variation by

- A** copying DNA exactly
- B** exchanging segments between homologous chromosomes
- C** removing chromosomes
- D** joining two gametes

Solution 3.1

Method: Three sources of variation

- A copying DNA exactly
- B exchanging segments between homologous chromosomes** 
- C removing chromosomes
- D joining two gametes

Worked steps

B — exchanging segments between homologous chromosomes.

Exam-style 3.2 ■ 3 marks

A student lists sources of genetic variation.

- (a) Name three sources from meiosis and reproduction.
- (b) Explain how independent assortment creates variation.

Solution 3.2

Method: Three sources of variation

Worked steps

(a) Crossing over, independent assortment, random fertilization **B1 B1 B1**. (b) Each homologous pair aligns independently, so the maternal and paternal chromosomes are mixed into gametes in many different combinations **M1 A1**.

Exam-style 3.3 ■ 2 marks

Explain why sexual reproduction produces more genetic variation than asexual reproduction.

Solution 3.3

Method: Three sources of variation

Worked steps

Sexual reproduction combines crossing over, independent assortment, and random fertilization to mix alleles from two parents, whereas asexual reproduction copies one parent's genome, giving little variation **M1** **A1**.